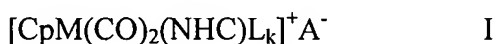


CLAIMS:

1. An organometallic complex comprising:  
a catalyst containing a transition metal, at least a ligand and a component having the formula  $GAr^F$ , wherein  $Ar^F$  is an aromatic ring system selected from the group consisting of phenyl, naphthalenyl, anthracenyl, fluorenyl, and indenyl, said aromatic ring system having at least a substituent selected from the group consisting of fluorine, hydrogen, hydrocarbyl and fluorinated hydrocarbyl, G is substituted or unsubstituted  $(CH_2)_n$  or  $(CF_2)_n$ , wherein n is from 1 to 30, wherein further one or more  $CH_2$  or  $CF_2$  groups are optionally replaced by NR, PR,  $SiR_2$ , BR, O or S, and R is hydrocarbyl or substituted hydrocarbyl,  $GAr^F$  being covalently bonded to either said transition metal or  
10 said ligand of said catalyst, thereby rendering said cationic organometallic complex liquid.

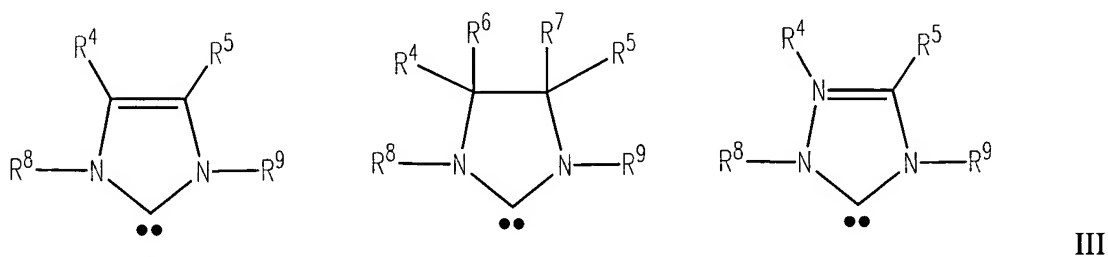
2. The organometallic complex according to claim 1, wherein said catalyst is represented by formula I



wherein M is a metal selected from molybdenum or tungsten ; Cp is substituted or unsubstituted cyclopentadienyl radical represented by the formula  $[C_5Q^1Q^2Q^3Q^4Q^5]$ , wherein  $Q^1$  to  $Q^5$  are independently selected from the group consisting of H radical,  $GAr^F$ ,  $C_{1-20}$  hydrocarbyl radical, substituted hydrocarbyl radical, hydrocarbyl radical

substituted by  $\text{GAR}^{\text{F}}$ , halogen radical, halogen-substituted hydrocarbyl radical,  $-\text{OR}$ ,  $-\text{C}(\text{O})\text{R}'$ ,  $-\text{CO}_2\text{R}'$ ,  $-\text{SiR}'_3$ ,  $-\text{NR}'\text{R}''$  wherein  $\text{R}'$  and  $\text{R}''$  are independently selected from the group consisting of H radical,  $\text{GAR}^{\text{F}}$ ,  $\text{C}_{1-20}$  hydrocarbyl radical, halogen radical, and halogen-substituted hydrocarbyl radical, wherein said  $\text{Q}^1$  to  $\text{Q}^5$  radicals can be optionally linked to each other to form a stable bridging group; NHC is any N-heterocyclic carbene ligand, L is either any neutral ligand, wherein k is a number from 0 to 1 or L is an anionic ligand wherein k is 2, and  $\text{A}^-$  is an anion.

3. The organometallic complex according to claim 2, wherein NHC is an unsubstituted or substituted N-heterocyclic carbene ligand selected from the group consisting of carbenes represented by formula III



wherein  $\text{R}^4$ ,  $\text{R}^5$ ,  $\text{R}^6$ ,  $\text{R}^7$ ,  $\text{R}^8$  and  $\text{R}^9$  are each independently hydrogen,  $\text{GAR}^{\text{F}}$ , halogen or a substituent selected from the group consisting of  $\text{C}_1$ - $\text{C}_{20}$  alkyl,  $\text{C}_2$ - $\text{C}_{20}$  alkenyl,  $\text{C}_2$ - $\text{C}_{20}$  alkynyl, aryl,  $\text{C}_1$ - $\text{C}_{20}$  carboxylate,  $\text{C}_1$ - $\text{C}_{20}$  alkoxy,  $\text{C}_2$ - $\text{C}_{20}$  alkenyloxy,  $\text{C}_2$ - $\text{C}_{20}$  alkynyloxy, aryloxy,  $\text{C}_2$ - $\text{C}_{20}$  alkoxycarbonyl,  $\text{C}_1$ - $\text{C}_{20}$  alkylthiol, aryl thiol,  $\text{C}_1$ - $\text{C}_{20}$  alkylsulfonyl and  $\text{C}_1$ - $\text{C}_{20}$  alkylsulfinyl, wherein further each  $\text{R}^4$ ,  $\text{R}^5$ ,  $\text{R}^6$ ,  $\text{R}^7$ ,  $\text{R}^8$  and  $\text{R}^9$  is optionally substituted with one or more moieties selected from the group consisting of  $\text{C}_1$ - $\text{C}_{20}$  hydrocarbyl, hydrocarbyl radical substituted by  $\text{GAR}^{\text{F}}$ ,  $\text{C}_1$ - $\text{C}_{20}$  alkoxy, hydroxyl, thiol, thioether, ketone, aldehyde, ester, ether, amine, imine, amide, nitro, carboxylic acid, disulfide, carbonate,

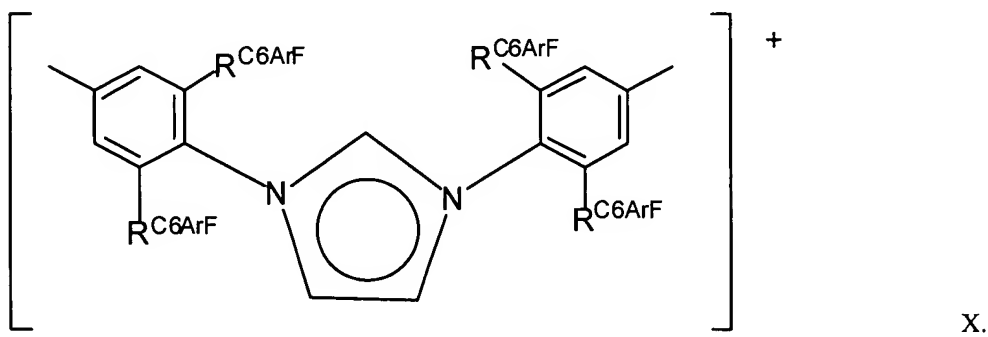
isocyanate, carbodiimide, carboalkoxy, carbamate and halogen, wherein  $R^4$ ,  $R^5$ ,  $R^6$ ,  $R^7$ ,  $R^8$  and  $R^9$  radicals are optionally linked to each other to form a stable bridging group.

4. The organometallic complex according to claim 2, wherein L is selected from the group consisting of a hydrocarbon or halogenated hydrocarbon molecule, a dihydrogen ( $H_2$ ) or hydrosilane, a ketone, an aldehyde or an ester, an alkoxysilane, ether or alcohol molecule, a combination of two anionic ligands selected from the group consisting of hydride ( $H^-$ ), silyl ( $SiR^{10}R^{11}R^{12}-$ ) and mixtures thereof, wherein  $R^{10}$ ,  $R^{11}$ ,  $R^{12}$  are independently hydrogen, halogen or a substituent selected from the group consisting of  $C_1$ - $C_{20}$  alkyl,  $C_2$ - $C_{20}$  alkenyl,  $C_2$ - $C_{20}$  alkynyl, aryl,  $C_1$ - $C_{20}$  carboxylate,  $C_1$ - $C_{20}$  alkoxy,  $C_2$ - $C_{20}$  alkenyloxy,  $C_2$ - $C_{20}$  alkynyloxy, aryloxy,  $C_2$ - $C_{20}$  alkoxycarbonyl,  $C_1$ - $C_{20}$  alkylthiol, aryl thiol,  $C_1$ - $C_{20}$  alkylsulfonyl and  $C_1$ - $C_{20}$  alkylsulfinyl, wherein further each  $R^{10}$ ,  $R^{11}$ ,  $R^{12}$  is optionally substituted with one or more moieties selected from the group consisting of  $C_1$ - $C_{20}$  hydrocarbyl,  $C_1$ - $C_{20}$  alkoxy, hydroxyl, thiol, thioether, ketone, aldehyde, ester, ether, amine, imine, amide, nitro, carboxylic acid, disulfide, carbonate, isocyanate, carbodiimide, carboalkoxy, carbamate and halogen.

5. The organometallic complex according to claim 1, wherein said anion ( $A^-$ ) is selected from the group consisting of  $BF_4^-$ ,  $PF_6^-$ ,  $SbF_6^-$ ,  $CF_3SO_3^-$ ,  $CB_{11}H_{12}^-$ ,  $CB_9H_{10}^-$ ,  $CB_9H_5X_5^-$ ,  $CB_{11}H_6X_6^-$ , wherein X is F, Cl, Br or I,  $HBR_3^-$ , wherein R is a hydrocarbyl or substituted hydrocarbyl, and  $[(M')Z^1 Z^2 \dots Z^n]^-$ ,  $M'$  is an element selected from atoms of group 13, n is the total number of Z ligands or n is 4, and  $Z^1$  to  $Z^n$  are independently selected from the group consisting of H radical,  $GAr^F$ ,  $C_{1-20}$  hydrocarbyl radical, substituted hydrocarbyl radical, hydrocarbyl radicals substituted by  $GAr^F$ , halogens,

halogen-substituted hydrocarbyl radical, hydrocarbyl-, halogen-substituted hydrocarbyl organometalloid radical, -OR, -C(O)R', -CO<sub>2</sub>R', and -NR'R'', wherein R' and R'' are  
 10 independently selected from the group consisting of H radicals, C<sub>1-20</sub> hydrocarbyl radicals, halogens, and halogen-substituted hydrocarbyl radical; said Z<sup>1</sup> to Z<sup>n</sup> radicals optionally linked to each other to form a stable bridging group.

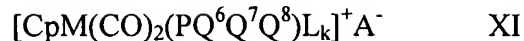
6. The organometallic complex according to claim 5, wherein said catalyst is selected from the group consisting of (1, 5-cyclooctadiene)Ir(PR<sup>C<sub>6</sub>ArF</sup><sub>3</sub>)(pyridine)<sup>+</sup>PF<sub>6</sub><sup>-</sup>, (C<sub>5</sub>H<sub>5</sub>)W(CO)<sub>2</sub>(PR<sup>C<sub>6</sub>ArF</sup><sub>3</sub>)(Et<sub>2</sub>C=O)<sup>+</sup>B(C<sub>6</sub>F<sub>5</sub>)<sub>4</sub><sup>-</sup>, and (C<sub>5</sub>H<sub>5</sub>)W(CO)<sub>2</sub>(Im<sup>ArC<sub>6</sub>ArF</sup>)<sup>+</sup>B(C<sub>6</sub>F<sub>5</sub>)<sub>4</sub><sup>-</sup>, wherein R<sup>C<sub>6</sub>ArF</sup> is C<sub>6</sub>F<sub>5</sub>(CH<sub>2</sub>)<sub>6</sub>, and Im<sup>ArC<sub>6</sub>ArF</sup> is represented by formula X



7. The organometallic complex according to claim 1, wherein said catalytic reaction is solvent-free.

8. The organometallic complex according to claim 1, wherein said cationic organometallic complex is a stable liquid clathrate.

9. The organometallic complex according to claim 1, wherein said catalyst is represented by the formula XI



wherein M is a molybdenum or tungsten atom; Cp is substituted or unsubstituted cyclopentadienyl radical represented by the formula  $[\text{C}_5\text{Q}^1\text{Q}^2\text{Q}^3\text{Q}^4\text{Q}^5]$ , wherein  $\text{Q}^1$  to  $\text{Q}^5$  are independently selected from the group consisting of H radical,  $\text{GAR}^{\text{F}}$ ,  $\text{C}_{1-20}$  hydrocarbyl radical substituted hydrocarbyl radical, including hydrocarbyl radicals substituted by  $\text{GAR}^{\text{F}}$ , halogen radical, halogen substituted hydrocarbyl radical, -OR, -C(O)R', -CO<sub>2</sub>R', -SiR'<sub>3</sub>, -NR'R'' wherein R' and R'' are independently selected from the group consisting of H radical,  $\text{C}_{1-20}$  hydrocarbyl radical, halogen radical, and halogen-substituted hydrocarbyl radical, wherein said  $\text{Q}^1$  to  $\text{Q}^5$  radicals can be optionally linked to each other to form a stable bridging group;  $\text{PQ}^6\text{Q}^7\text{Q}^8$  is a phosphine ligand, wherein  $\text{Q}^6$ ,  $\text{Q}^7$ ,  $\text{Q}^8$  represent three groups independently selected from the group consisting of H radical,  $\text{GAR}^{\text{F}}$ ,  $\text{C}_{1-20}$  hydrocarbyl radical substituted hydrocarbyl radical, including hydrocarbyl radicals substituted by  $\text{GAR}^{\text{F}}$ , halogen radical, halogen substituted hydrocarbyl radical, -OR, -C(O)R', -CO<sub>2</sub>R', -SiR'<sub>3</sub>, -NR'R'' wherein R' and R'' are independently selected from the group consisting of H radical,  $\text{C}_{1-20}$  hydrocarbyl radical, halogen radical, and halogen-substituted hydrocarbyl radical, wherein all three  $\text{Q}^6$ ,  $\text{Q}^7$ ,  $\text{Q}^8$  groups can be the same or different or two of the three groups can be the same; L is either any neutral ligand, wherein k is a number from 0 to 1 or L is an anionic ligand wherein k is 2, and A<sup>-</sup> is an anion.

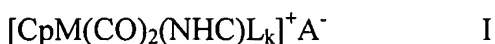
10. The organometallic complex according to claim 9, wherein L is selected from the group consisting of a hydrocarbon or halogenated hydrocarbon molecule, a dihydrogen (H<sub>2</sub>) or hydrosilane, a ketone, an aldehyde or an ester, an alkoxysilane, ether

or alcohol molecule, a combination of two anionic ligands selected from the group consisting of hydride ( $H^-$ ), silyl ( $SiR^{10}R^{11}R^{12}-$ ) and mixtures thereof, wherein  $R^{10}$ ,  $R^{11}$ ,  $R^{12}$  are independently hydrogen, halogen or a substituent selected from the group consisting of  $C_1$ - $C_{20}$  alkyl,  $C_2$ - $C_{20}$  alkenyl,  $C_2$ - $C_{20}$  alkynyl, aryl,  $C_1$ - $C_{20}$  carboxylate,  $C_1$ - $C_{20}$  alkoxy,  $C_2$ - $C_{20}$  alkenyloxy,  $C_2$ - $C_{20}$  alkynyloxy, aryloxy,  $C_2$ - $C_{20}$  alkoxycarbonyl,  $C_1$ - $C_{20}$  alkylthiol, aryl thiol,  $C_1$ - $C_{20}$  alkylsulfonyl and  $C_1$ - $C_{20}$  alkylsulfinyl, wherein further each  $R^{10}$ ,  $R^{11}$ ,  $R^{12}$  is optionally substituted with one or more moieties selected from the group consisting of  $C_1$ - $C_{20}$  hydrocarbyl,  $C_1$ - $C_{20}$  alkoxy, hydroxyl, thiol, thioether, ketone, aldehyde, ester, ether, amine, imine, amide, nitro, carboxylic acid, disulfide, carbonate, isocyanate, carbodiimide, carboalkoxy, carbamate and halogen; wherein further the anion  $A^-$  is selected from the group consisting of  $BF_4^-$ ,  $PF_6^-$ ,  $SbF_6^-$ ,  $CF_3SO_3^-$ ,  $CB_{11}H_{12}^-$ ,  $CB_9H_{10}^-$ ,  $CB_9H_5X_5^-$ ,  $CB_{11}H_6X_6^-$ , wherein X is F Cl, Br or I,  $HBR_3^-$ , wherein R is a hydrocarbyl or substituted hydrocarbyl, and  $[(M')Z^1 Z^2 \dots Z^n]$ , M' is an element selected from atoms of group 13, n is the total number of Z ligands or n is 4, and  $Z^1$  to  $Z^n$  are independently selected from the group consisting of H radical,  $GAr^F$ ,  $C_{1-20}$  hydrocarbyl radical, substituted hydrocarbyl radical, hydrocarbyl radicals substituted by  $GAr^F$ , halogens, halogen-substituted hydrocarbyl radical, hydrocarbyl-, halogen-substituted hydrocarbyl organometalloid radical, -OR, -C(O)R', -CO<sub>2</sub>R', and -NR'R'', wherein R' and R'' are independently selected from the group consisting of H radicals,  $C_{1-20}$  hydrocarbyl radicals, halogens, and halogen-substituted hydrocarbyl radical; said  $Z^1$  to  $Z^n$  radicals optionally linked to each other to form a stable bridging group.

11. A process for conducting a catalytic reaction, said process comprising:  
contacting a reaction mixture including reactants with an organometallic complex comprising a catalyst containing a transition metal, at least a ligand and a component having the formula  $\text{GAR}^{\text{F}}$ , wherein  $\text{Ar}^{\text{F}}$  is an aromatic ring system selected from the group consisting of phenyl, naphthalenyl, anthracenyl, fluorenyl and indenyl, said aromatic ring system having at least a substituent selected from the group consisting of fluorine, hydrogen, hydrocarbyl and fluorinated hydrocarbyl, G is substituted or unsubstituted  $(\text{CH}_2)_n$  or  $(\text{CF}_2)_n$ , wherein n is from 1 to 30, wherein further one or more  $\text{CH}_2$  or  $\text{CF}_2$  groups are optionally replaced by NR, PR,  $\text{SiR}_2$ , BR, O or S, and R is
- 10 hydrocarbyl or substituted hydrocarbyl,  $\text{GAR}^{\text{F}}$  being covalently bonded to either said transition metal or said ligand of said catalyst, thereby rendering said cationic organometallic complex liquid.

recovering said catalyst after products have formed.

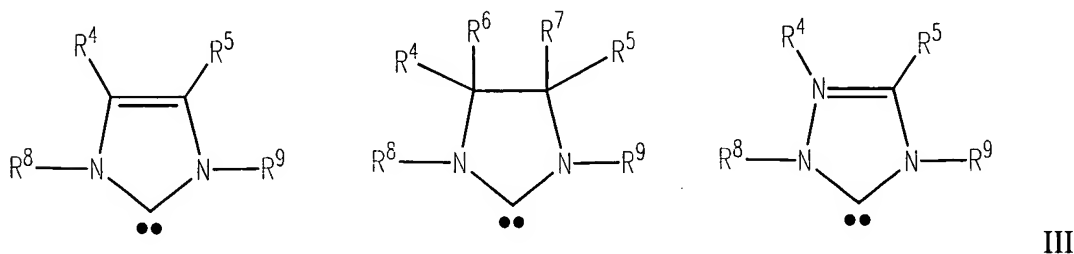
12. The process according to claim 11, wherein said catalyst is represented by formula I



wherein M is a metal selected from molybdenum or tungsten; Cp is substituted or unsubstituted cyclopentadienyl radical represented by the formula  $[\text{C}_5\text{Q}^1\text{Q}^2\text{Q}^3\text{Q}^4\text{Q}^5]$ , wherein  $\text{Q}^1$  to  $\text{Q}^5$  are independently selected from the group consisting of H radical,  $\text{GAR}^{\text{F}}$ ,  $\text{C}_{1-20}$  hydrocarbyl radical, substituted hydrocarbyl radical, hydrocarbyl radical substituted by  $\text{GAR}^{\text{F}}$ , halogen radical, halogen-substituted hydrocarbyl radical, -OR, - $\text{C}(\text{O})\text{R}'$ ,  $-\text{CO}_2\text{R}'$ ,  $-\text{SiR}'_3$ ,  $-\text{NR}'\text{R}''$  wherein  $\text{R}'$  and  $\text{R}''$  are independently selected from the

10 group consisting of H radical,  $\text{GAR}^{\text{F}}$ ,  $\text{C}_{1-20}$  hydrocarbyl radical, halogen radical, and halogen-substituted hydrocarbyl radical, wherein said  $\text{Q}^1$  to  $\text{Q}^5$  radicals can be optionally linked to each other to form a stable bridging group; NHC is any N-heterocyclic carbene ligand, L is either any neutral ligand, wherein k is a number from 0 to 1 or L is an anionic ligand wherein k is 2, and  $\text{A}^-$  is an anion.

13. The process according to claim 11, wherein NHC is an unsubstituted or substituted N-heterocyclic carbene selected from the group consisting of carbenes represented by formula III



wherein  $\text{R}^4$ ,  $\text{R}^5$ ,  $\text{R}^6$ ,  $\text{R}^7$ ,  $\text{R}^8$  and  $\text{R}^9$  are each independently hydrogen,  $\text{GAR}^{\text{F}}$ , halogen or a substituent selected from the group consisting of  $\text{C}_1\text{-C}_{20}$  alkyl,  $\text{C}_2\text{-C}_{20}$  alkenyl,  $\text{C}_2\text{-C}_{20}$  alkynyl, aryl,  $\text{C}_1\text{-C}_{20}$  carboxylate,  $\text{C}_1\text{-C}_{20}$  alkoxy,  $\text{C}_2\text{-C}_{20}$  alkenyloxy,  $\text{C}_2\text{-C}_{20}$  alkynyloxy, aryloxy,  $\text{C}_2\text{-C}_{20}$  alkoxycarbonyl,  $\text{C}_1\text{-C}_{20}$  alkylthiol, aryl thiol,  $\text{C}_1\text{-C}_{20}$  alkylsulfonyl and  $\text{C}_1\text{-C}_{20}$  alkylsulfinyl, wherein further each  $\text{R}^4$ ,  $\text{R}^5$ ,  $\text{R}^6$ ,  $\text{R}^7$ ,  $\text{R}^8$  and  $\text{R}^9$  is optionally substituted with one or more moieties selected from the group consisting of  $\text{C}_1\text{-C}_{20}$  hydrocarbyl, hydrocarbyl radical substituted by  $\text{GAR}^{\text{F}}$ ,  $\text{C}_1\text{-C}_{20}$  alkoxy, hydroxyl, thiol, thioether, ketone, aldehyde, ester, ether, amine, imine, amide, nitro, carboxylic acid, disulfide, carbonate,

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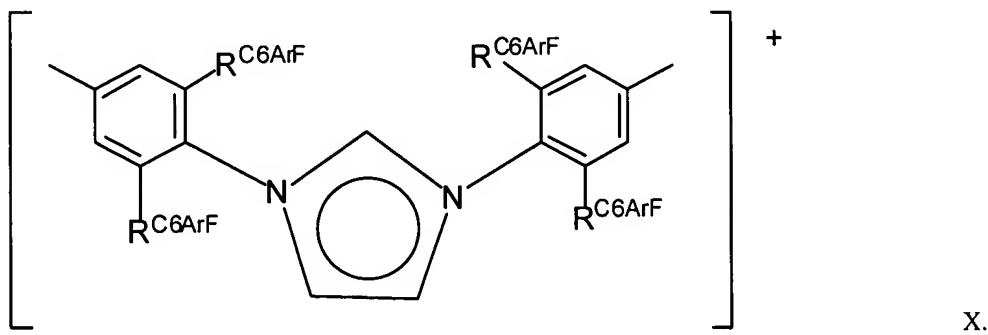
isocyanate, carbodiimide, carboalkoxy, carbamate and halogen, wherein  $R^4$ ,  $R^5$ ,  $R^6$ ,  $R^7$ ,  $R^8$  and  $R^9$  radicals are optionally linked to each other to form a stable bridging group.

14. The process according to claim 11, wherein L is selected from the group consisting of a hydrocarbon or halogenated hydrocarbon molecule, a dihydrogen ( $H_2$ ) or hydrosilane, a ketone, an aldehyde or an ester, an alkoxy silane, ether or alcohol molecule, a combination of two anionic ligands selected from the group consisting of hydride ( $H^-$ ), silyl ( $SiR^{10}R^{11}R^{12}$ ) $^-$  and mixtures thereof, wherein  $R^{10}$ ,  $R^{11}$ ,  $R^{12}$  are independently hydrogen, halogen or a substituent selected from the group consisting of  $C_1$ - $C_{20}$  alkyl,  $C_2$ - $C_{20}$  alkenyl,  $C_2$ - $C_{20}$  alkynyl, aryl,  $C_1$ - $C_{20}$  carboxylate,  $C_1$ - $C_{20}$  alkoxy,  $C_2$ - $C_{20}$  alkenyloxy,  $C_2$ - $C_{20}$  alkynyloxy, aryloxy,  $C_2$ - $C_{20}$  alkoxycarbonyl,  $C_1$ - $C_{20}$  alkylthiol, aryl thiol,  $C_1$ - $C_{20}$  alkylsulfonyl and  $C_1$ - $C_{20}$  alkylsulfinyl, wherein further each  $R^{10}$ ,  $R^{11}$ ,  $R^{12}$  is optionally substituted with one or more moieties selected from the group consisting of  $C_1$ - $C_{20}$  hydrocarbyl,  $C_1$ - $C_{20}$  alkoxy, hydroxyl, thiol, thioether, ketone, aldehyde, ester, ether, amine, imine, amide, nitro, carboxylic acid, disulfide, carbonate, isocyanate, carbodiimide, carboalkoxy, carbamate and halogen.

15. The process according to claim 11, wherein said anion ( $A^-$ ) is selected from the group consisting of  $BF_4^-$ ,  $PF_6^-$ ,  $SbF_6^-$ ,  $CF_3SO_3^-$ ,  $CB_{11}H_{12}^-$ ,  $CB_9H_{10}^-$ ,  $CB_9H_5X_5^-$ ,  $CB_{11}H_6X_6^-$ , wherein X is F, Cl, Br or I,  $HBR_3^-$ , wherein R is a hydrocarbyl or substituted hydrocarbyl, and  $[(M')Z^1 Z^2 \dots Z^n]^-$ ,  $M'$  is an element selected from atoms of group 13, n is the total number of Z ligands or n is 4, and  $Z^1$  to  $Z^n$  are independently selected from the group consisting of H radical,  $GAr^F$ ,  $C_{1-20}$  hydrocarbyl radical, substituted hydrocarbyl radical, hydrocarbyl radicals substituted by  $GAr^F$ , halogens, halogen-substituted

hydrocarbyl radical, hydrocarbyl-, halogen-substituted hydrocarbyl organometalloid radical, -OR, -C(O)R', -CO<sub>2</sub>R', and -NR'R'', wherein R' and R'' are independently  
 10 selected from the group consisting of H radicals, C<sub>1-20</sub> hydrocarbyl radicals, halogens, and halogen-substituted hydrocarbyl radical; said Z<sup>1</sup> to Z<sup>n</sup> radicals optionally linked to each other to form a stable bridging group.

16. The process according to claim 11, wherein said catalyst is selected from the group consisting of (1, 5-cyclooctadiene)Ir(PR<sup>C6ArF</sup><sub>3</sub>)(pyridine)<sup>+</sup>PF<sub>6</sub><sup>-</sup>, (C<sub>5</sub>H<sub>5</sub>)W(CO)<sub>2</sub>W(PR<sup>C6ArF</sup><sub>3</sub>)(Et<sub>2</sub>C=O)<sup>+</sup>B(C<sub>6</sub>F<sub>5</sub>)<sub>4</sub><sup>-</sup>, and (C<sub>5</sub>H<sub>5</sub>)W(CO)<sub>2</sub>W(Im<sup>ArC6ArF</sup>)<sup>+</sup>B(C<sub>6</sub>F<sub>5</sub>)<sub>4</sub><sup>-</sup>, wherein R<sup>C6ArF</sup> is C<sub>6</sub>F<sub>5</sub>(CH<sub>2</sub>)<sub>6</sub>, and Im<sup>ArC6ArF</sup> is represented by formula X



17. The process according to claim 11, wherein said catalytic reaction is solvent-free.

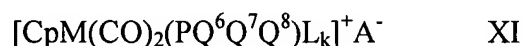
18. The process according to claim 17, wherein said solvent-free catalytic reaction is selected from the group consisting of hydrogenation of an organic compound, and hydrosilylation of an organic compound, wherein said organic compound contains at least one reducible functional group selected from the group consisting of R(C=O)R<sup>1</sup>,

$R(C=O)H$ , and  $R(CO_2)R^1$ , wherein  $R$  and  $R^1$  are each independently selected from  $H$ ,  $C_{1-30}$  hydrocarbyl radicals or substituted hydrocarbyl radicals.

19. The process according to claim 11, wherein said contacting occurs at a temperature from about  $20^\circ\text{C}$  to about  $150^\circ\text{C}$ .

20. The process according to claim 11, further comprising cooling the reaction mixture from about  $0^\circ\text{C}$  to about  $-78^\circ\text{C}$ .

21. The process according to claim 11, wherein said catalyst is represented by formula XI



wherein  $M$  is a molybdenum or tungsten atom;  $\text{Cp}$  is substituted or unsubstituted cyclopentadienyl radical represented by the formula  $[\text{C}_5\text{Q}^1\text{Q}^2\text{Q}^3\text{Q}^4\text{Q}^5]$ , wherein  $\text{Q}^1$  to  $\text{Q}^5$  are independently selected from the group consisting of  $H$  radical,  $\text{GAr}^F$ ,  $C_{1-20}$  hydrocarbyl radical substituted hydrocarbyl radical, including hydrocarbyl radicals substituted by  $\text{GAr}^F$ , halogen radical, halogen substituted hydrocarbyl radical,  $-\text{OR}$ ,  $-\text{C}(\text{O})\text{R}'$ ,  $-\text{CO}_2\text{R}'$ ,  $-\text{SiR}'_3$ ,  $-\text{NR}'\text{R}''$  wherein  $\text{R}'$  and  $\text{R}''$  are independently selected from the group consisting of  $H$  radical,  $C_{1-20}$  hydrocarbyl radical, halogen radical, and halogen-substituted hydrocarbyl radical, wherein said  $\text{Q}^1$  to  $\text{Q}^5$  radicals can be optionally linked to each other to form a stable bridging group;  $\text{PQ}^6\text{Q}^7\text{Q}^8$  is a phosphine ligand, wherein  $\text{Q}^6$ ,  $\text{Q}^7$ ,  $\text{Q}^8$  represent three groups independently selected from the group consisting of  $H$  radical,  $\text{GAr}^F$ ,  $C_{1-20}$  hydrocarbyl radical substituted hydrocarbyl radical, including hydrocarbyl radicals substituted by  $\text{GAr}^F$ , halogen radical, halogen substituted hydrocarbyl radical,  $-\text{OR}$ ,  $-\text{C}(\text{O})\text{R}'$ ,  $-\text{CO}_2\text{R}'$ ,  $-\text{SiR}'_3$ ,  $-\text{NR}'\text{R}''$  wherein  $\text{R}'$  and  $\text{R}''$  are

independently selected from the group consisting of H radical, C<sub>1-20</sub> hydrocarbyl radical, halogen radical, and halogen-substituted hydrocarbyl radical, wherein all three Q<sup>6</sup>, Q<sup>7</sup>, Q<sup>8</sup> groups can be the same or different or two of the three groups can be the same; L is either  
20 any neutral ligand, wherein k is a number from 0 to 1 or L is an anionic ligand wherein k is 2, and A<sup>-</sup> is an anion.

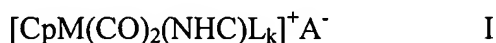
22. The organometallic complex according to claim 21, wherein L is selected from the group consisting of a hydrocarbon or halogenated hydrocarbon molecule, a dihydrogen (H<sub>2</sub>) or hydrosilane, a ketone, an aldehyde or an ester, an alkoxysilane, ether or alcohol molecule, a combination of two anionic ligands selected from the group consisting of hydride (H<sup>-</sup>), silyl (SiR<sup>10</sup>R<sup>11</sup>R<sup>12</sup>)<sup>-</sup> and mixtures thereof, wherein R<sup>10</sup>, R<sup>11</sup>, R<sup>12</sup> are independently hydrogen, halogen or a substituent selected from the group consisting of C<sub>1</sub>-C<sub>20</sub> alkyl, C<sub>2</sub>-C<sub>20</sub> alkenyl, C<sub>2</sub>-C<sub>20</sub> alkynyl, aryl, C<sub>1</sub>-C<sub>20</sub> carboxylate, C<sub>1</sub>-C<sub>20</sub> alkoxy, C<sub>2</sub>-C<sub>20</sub> alkenyloxy, C<sub>2</sub>-C<sub>20</sub> alkynyloxy, aryloxy, C<sub>2</sub>-C<sub>20</sub> alkoxycarbonyl, C<sub>1</sub>-C<sub>20</sub> alkylthiol, aryl thiol, C<sub>1</sub>-C<sub>20</sub> alkylsulfonyl and C<sub>1</sub>-C<sub>20</sub> alkylsulfinyl, wherein further each R<sup>10</sup>, R<sup>11</sup>,  
10 R<sup>12</sup> is optionally substituted with one or more moieties selected from the group consisting of C<sub>1</sub>-C<sub>20</sub> hydrocarbyl, C<sub>1</sub>-C<sub>20</sub> alkoxy, hydroxyl, thiol, thioether, ketone, aldehyde, ester, ether, amine, imine, amide, nitro, carboxylic acid, disulfide, carbonate, isocyanate, carbodiimide, carboalkoxy, carbamate and halogen; wherein further the anion A<sup>-</sup> is selected from the group consisting of BF<sub>4</sub><sup>-</sup>, PF<sub>6</sub><sup>-</sup>, SbF<sub>6</sub><sup>-</sup>, CF<sub>3</sub>SO<sub>3</sub><sup>-</sup>, CB<sub>11</sub>H<sub>12</sub><sup>-</sup>, CB<sub>9</sub>H<sub>10</sub><sup>-</sup>, CB<sub>9</sub>H<sub>5</sub>X<sub>5</sub><sup>-</sup>, CB<sub>11</sub>H<sub>6</sub>X<sub>6</sub><sup>-</sup>, wherein X is F Cl, Br or I, HBR<sub>3</sub><sup>-</sup>, wherein R is a hydrocarbyl or substituted hydrocarbyl, and [(M')Z<sup>1</sup> Z<sup>2</sup> ... Z<sup>n</sup> ], M' is an element selected from atoms of group 13, n is the total number of Z ligands or n is 4, and Z<sup>1</sup> to Z<sup>n</sup> are independently

selected from the group consisting of H radical,  $\text{GAr}^{\text{F}}$ ,  $\text{C}_{1-20}$  hydrocarbyl radical, substituted hydrocarbyl radical, hydrocarbyl radicals substituted by  $\text{GAr}^{\text{F}}$ , halogens, halogen-substituted hydrocarbyl radical, hydrocarbyl-, halogen-substituted hydrocarbyl organometalloid radical, -OR, -C(O)R', -CO<sub>2</sub>R', and -NR'R'', wherein R' and R'' are independently selected from the group consisting of H radicals,  $\text{C}_{1-20}$  hydrocarbyl radicals, halogens, and halogen-substituted hydrocarbyl radical; said  $\text{Z}^1$  to  $\text{Z}^n$  radicals optionally linked to each other to form a stable bridging group.

23. A method of preparing an organometallic complex including a catalyst containing a transition metal, a ligand and a component  $\text{GAr}^{\text{F}}$  wherein  $\text{Ar}^{\text{F}}$  is an aromatic ring system selected from the group consisting of phenyl, naphthalenyl, anthracenyl, fluorenyl and indenyl, said aromatic ring system having at least a substituent selected from the group consisting of fluorine, hydrogen, hydrocarbyl and fluorinated hydrocarbyl, G is substituted or unsubstituted  $(\text{CH}_2)_n$  or  $(\text{CF}_2)_n$ , wherein n is from 1 to 30, wherein further one or more  $\text{CH}_2$  or  $\text{CF}_2$  groups are optionally replaced by NR, PR,  $\text{SiR}_2$ , BR, O or S, and R is hydrocarbyl or substituted hydrocarbyl,  $\text{GAr}^{\text{F}}$  being covalently bonded to either said transition metal or said ligand of said catalyst, thereby rendering said cationic organometallic complex liquid, said method comprising:

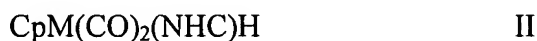
- (i) providing  $\text{GAr}^{\text{F}}$ ,
- (ii) covalently bonding  $\text{GAr}^{\text{F}}$  to either a metal or a ligand of said catalyst.

24. The method of claim 23, wherein said catalyst is of the formula I



wherein M is a metal selected from molybdenum or tungsten ; Cp is substituted or unsubstituted cyclopentadienyl radical represented by the formula  $[C_5Q^1Q^2Q^3Q^4Q^5]$ , wherein  $Q^1$  to  $Q^5$  are independently selected from the group consisting of H radical,  $GAr^F$ ,  $C_{1-20}$  hydrocarbyl radical, substituted hydrocarbyl radical, hydrocarbyl radical substituted by  $GAr^F$ , halogen radical, halogen-substituted hydrocarbyl radical, -OR, -C(O)R', -CO<sub>2</sub>R', -SiR'<sub>3</sub>, -NR'R'' wherein R' and R'' are independently selected from the group consisting of H radical,  $GAr^F$ ,  $C_{1-20}$  hydrocarbyl radical, halogen radical, and halogen-substituted hydrocarbyl radical, wherein said  $Q^1$  to  $Q^5$  radicals can be optionally linked to each other to form a stable bridging group; NHC is any N-heterocyclic carbene ligand, L is either any neutral ligand, wherein k is a number from 0 to 1 or L is an anionic ligand wherein k is 2, and A<sup>-</sup> is an anion,

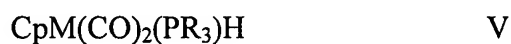
wherein said catalyst is prepared by reacting a metal hydride represented by the formula II:



with a hydride removing agent selected from BR<sub>3</sub> or a compound represented by formula Y<sup>+</sup>A<sup>-</sup>, wherein Y is selected from the group consisting of (aryl)<sub>3</sub>C<sup>+</sup>, (aryl)<sub>2</sub>HC<sup>+</sup>, C<sub>7</sub>H<sub>7</sub><sup>+</sup>, R<sub>3</sub>NH<sup>+</sup>, Ag<sup>+</sup> and (C<sub>5</sub>R<sub>5</sub>)<sub>2</sub>Fe<sup>+</sup>, wherein R is a hydrocarbyl or substituted hydrocarbyl, A<sup>-</sup> is selected from the group consisting of BF<sub>4</sub><sup>-</sup>, PF<sub>6</sub><sup>-</sup>, SbF<sub>6</sub><sup>-</sup>, CF<sub>3</sub>SO<sub>3</sub><sup>-</sup>, CB<sub>11</sub>H<sub>12</sub><sup>-</sup>, CB<sub>9</sub>H<sub>10</sub><sup>-</sup>, CB<sub>9</sub>H<sub>5</sub>X<sub>5</sub><sup>-</sup>, CB<sub>11</sub>H<sub>6</sub>X<sub>6</sub><sup>-</sup>, wherein X is F Cl, Br or I, HBR<sub>3</sub><sup>-</sup>, wherein R is a hydrocarbyl or substituted hydrocarbyl, and [(M')Z<sup>1</sup> Z<sup>2</sup>...Z<sup>n</sup>]<sup>-</sup>, M' is an element selected from atoms of group 13, n is the total number of Z ligands or n is 4, and Z<sup>1</sup> to Z<sup>n</sup> are independently selected from the group consisting of H radical,  $GAr^F$ ,  $C_{1-20}$  hydrocarbyl radical,

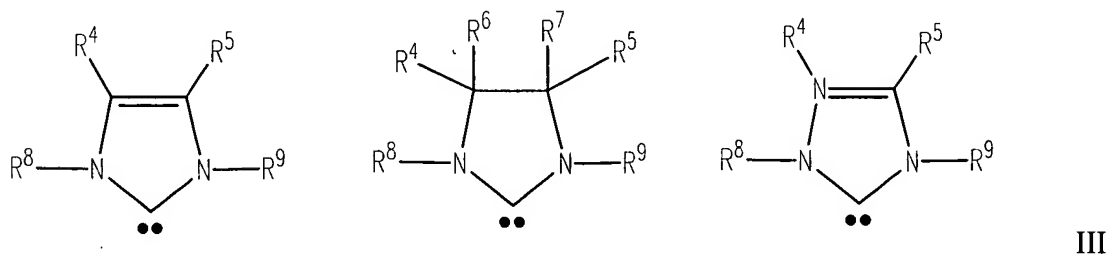
substituted hydrocarbyl radical, hydrocarbyl radicals substituted by  $\text{GAr}^F$ , halogens, halogen-substituted hydrocarbyl radical, hydrocarbyl-, halogen-substituted hydrocarbyl  
 40 organometalloid radical, -OR, -C(O)R', -CO<sub>2</sub>R', and -NR'R'', wherein R' and R'' are independently selected from the group consisting of H radicals, C<sub>1-20</sub> hydrocarbyl radicals, halogens, and halogen-substituted hydrocarbyl radical; said Z<sup>1</sup> to Z<sup>n</sup> radicals optionally linked to each other to form a stable bridging group.

25. The method according to claim 24, wherein said metal hydride is prepared by reacting a phosphine hydride represented by the formula V



wherein R is any C<sub>1</sub>-C<sub>20</sub> hydrocarbyl group with said NHC.

26. The method according to claim 24, wherein NHC is an unsubstituted or substituted N-heterocyclic carbene ligand selected from the group consisting of carbenes represented by formula III

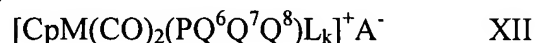


wherein R<sup>4</sup>, R<sup>5</sup>, R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup> and R<sup>9</sup> are each independently hydrogen,  $\text{GAr}^F$ , halogen or a  
 10 substituent selected from the group consisting of C<sub>1</sub>-C<sub>20</sub> alkyl, C<sub>2</sub>-C<sub>20</sub> alkenyl, C<sub>2</sub>-C<sub>20</sub> alkynyl, aryl, C<sub>1</sub>-C<sub>20</sub> carboxylate, C<sub>1</sub>-C<sub>20</sub> alkoxy, C<sub>2</sub>-C<sub>20</sub> alkenyloxy, C<sub>2</sub>-C<sub>20</sub> alkynyloxy, aryloxy, C<sub>2</sub>-C<sub>20</sub> alkoxycarbonyl, C<sub>1</sub>-C<sub>20</sub> alkylthiol, aryl thiol, C<sub>1</sub>-C<sub>20</sub> alkylsulfonyl and C<sub>1</sub>-C<sub>20</sub> alkylsulfinyl, wherein further each R<sup>4</sup>, R<sup>5</sup>, R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup> and R<sup>9</sup> is optionally substituted

with one or more moieties selected from the group consisting of C<sub>1</sub>-C<sub>20</sub> hydrocarbyl, hydrocarbyl radical substituted by GAR<sup>F</sup>, C<sub>1</sub>-C<sub>20</sub> alkoxy, hydroxyl, thiol, thioether, ketone, aldehyde, ester, ether, amine, imine, amide, nitro, carboxylic acid, disulfide, carbonate, isocyanate, carbodiimide, carboalkoxy, carbamate and halogen, wherein R<sup>4</sup>, R<sup>5</sup>, R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup> and R<sup>9</sup> radicals are optionally linked to each other to form a stable bridging group.

27. The method according to claim 24, wherein L is selected from the group consisting of a hydrocarbon or halogenated hydrocarbon molecule, a dihydrogen (H<sub>2</sub>) or hydrosilane, a ketone, an aldehyde or an ester, an alkoxy silane, ether or alcohol molecule, a combination of two anionic ligands selected from the group consisting of hydride (H<sup>-</sup>), silyl (SiR<sup>10</sup>R<sup>11</sup>R<sup>12</sup>)<sup>-</sup> and mixtures thereof, wherein R<sup>10</sup>, R<sup>11</sup>, R<sup>12</sup> are independently hydrogen, halogen or a substituent selected from the group consisting of C<sub>1</sub>-C<sub>20</sub> alkyl, C<sub>2</sub>-C<sub>20</sub> alkenyl, C<sub>2</sub>-C<sub>20</sub> alkynyl, aryl, C<sub>1</sub>-C<sub>20</sub> carboxylate, C<sub>1</sub>-C<sub>20</sub> alkoxy, C<sub>2</sub>-C<sub>20</sub> alkenyloxy, C<sub>2</sub>-C<sub>20</sub> alkynyloxy, aryloxy, C<sub>2</sub>-C<sub>20</sub> alkoxycarbonyl, C<sub>1</sub>-C<sub>20</sub> alkylthiol, aryl thiol, C<sub>1</sub>-C<sub>20</sub> alkylsulfonyl and C<sub>1</sub>-C<sub>20</sub> alkylsulfinyl, wherein further each R<sup>10</sup>, R<sup>11</sup>, R<sup>12</sup> is optionally substituted with one or more moieties selected from the group consisting of C<sub>1</sub>-C<sub>20</sub> hydrocarbyl, C<sub>1</sub>-C<sub>20</sub> alkoxy, hydroxyl, thiol, thioether, ketone, aldehyde, ester, ether, amine, imine, amide, nitro, carboxylic acid, disulfide, carbonate, isocyanate, carbodiimide, carboalkoxy, carbamate and halogen.

28. The method according to claim 23, wherein said catalyst is of the formula XII





wherein M is a molybdenum or tungsten atom; Cp is substituted or unsubstituted cyclopentadienyl radical represented by the formula  $[C_5Q^1Q^2Q^3Q^4Q^5]$ , wherein  $Q^1$  to  $Q^5$  are independently selected from the group consisting of H radical,  $GAr^F$ ,  $C_{1-20}$  hydrocarbyl radical substituted hydrocarbyl radical, including hydrocarbyl radicals substituted by  $GAr^F$ , halogen radical, halogen substituted hydrocarbyl radical, -OR, -C(O)R', -CO<sub>2</sub>R', -SiR'<sub>3</sub>, -NR'R'' wherein R' and R'' are independently selected from the group consisting of H radical,  $C_{1-20}$  hydrocarbyl radical, halogen radical, and halogen-substituted hydrocarbyl radical, wherein said  $Q^1$  to  $Q^5$  radicals can be optionally linked to each other to form a stable bridging group;  $PQ^6Q^7Q^8$  is a phosphine ligand, wherein  $Q^6$ ,  $Q^7$ ,  $Q^8$  represent three groups independently selected from the group consisting of H radical,  $GAr^F$ ,  $C_{1-20}$  hydrocarbyl radical substituted hydrocarbyl radical, including hydrocarbyl radicals substituted by  $GAr^F$ , halogen radical, halogen substituted hydrocarbyl radical, -OR, -C(O)R', -CO<sub>2</sub>R', -SiR'<sub>3</sub>, -NR'R'' wherein R' and R'' are independently selected from the group consisting of H radical,  $C_{1-20}$  hydrocarbyl radical, halogen radical, and halogen-substituted hydrocarbyl radical, wherein all three  $Q^6$ ,  $Q^7$ ,  $Q^8$  groups can be the same or different or two of the three groups can be the same; L is either any neutral ligand, wherein k is a number from 0 to 1 or L is an anionic ligand wherein k is 2, and  $A^-$  is an anion.

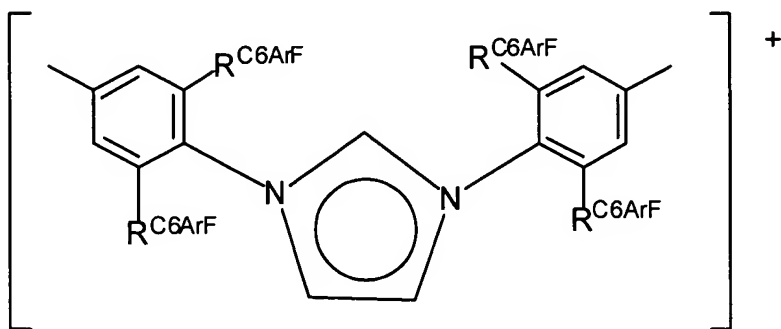
29. The organometallic complex of claim 28, wherein L is selected from the group consisting of a hydrocarbon or halogenated hydrocarbon molecule, a dihydrogen ( $H_2$ ) or hydrosilane, a ketone, an aldehyde or an ester, an alkoxysilane, ether or alcohol molecule, a combination of two anionic ligands selected from the group consisting of

hydride ( $H^-$ ), silyl ( $SiR^{10}R^{11}R^{12}$ ) $^-$  and mixtures thereof, wherein  $R^{10}$ ,  $R^{11}$ ,  $R^{12}$  are independently hydrogen, halogen or a substituent selected from the group consisting of  $C_1$ - $C_{20}$  alkyl,  $C_2$ - $C_{20}$  alkenyl,  $C_2$ - $C_{20}$  alkynyl, aryl,  $C_1$ - $C_{20}$  carboxylate,  $C_1$ - $C_{20}$  alkoxy,  $C_2$ - $C_{20}$  alkenyloxy,  $C_2$ - $C_{20}$  alkynyloxy, aryloxy,  $C_2$ - $C_{20}$  alkoxycarbonyl,  $C_1$ - $C_{20}$  alkylthiol, aryl thiol,  $C_1$ - $C_{20}$  alkylsulfonyl and  $C_1$ - $C_{20}$  alkylsulfinyl, wherein further each  $R^{10}$ ,  $R^{11}$ ,  $R^{12}$  is optionally substituted with one or more moieties selected from the group consisting of  $C_1$ - $C_{20}$  hydrocarbyl,  $C_1$ - $C_{20}$  alkoxy, hydroxyl, thiol, thioether, ketone, aldehyde, ester, ether, amine, imine, amide, nitro, carboxylic acid, disulfide, carbonate, isocyanate, carbodiimide, carboalkoxy, carbamate and halogen; wherein further the anion  $A^-$  is selected from the group consisting of  $BF_4^-$ ,  $PF_6^-$ ,  $SbF_6^-$ ,  $CF_3SO_3^-$ ,  $CB_{11}H_{12}^-$ ,  $CB_9H_{10}^-$ ,  $CB_9H_5X_5^-$ ,  $CB_{11}H_6X_6^-$ , wherein X is F Cl, Br or I,  $HBR_3^-$ , wherein R is a hydrocarbyl or substituted hydrocarbyl, and  $[(M')Z^1 Z^2 \dots Z^n]^-$ , M' is an element selected from atoms of group 13, n is the total number of Z ligands or n is 4, and  $Z^1$  to  $Z^n$  are independently selected from the group consisting of H radical,  $GAr^F$ ,  $C_{1-20}$  hydrocarbyl radical, substituted hydrocarbyl radical, hydrocarbyl radicals substituted by  $GAr^F$ , halogens, halogen-substituted hydrocarbyl radical, hydrocarbyl-, halogen-substituted hydrocarbyl organometalloid radical, -OR, -C(O)R', -CO<sub>2</sub>R', and -NR'R'', wherein R' and R'' are independently selected from the group consisting of H radicals,  $C_{1-20}$  hydrocarbyl radicals, halogens, and halogen-substituted hydrocarbyl radical; said  $Z^1$  to  $Z^n$  radicals optionally linked to each other to form a stable bridging group.

30. The method according to claim 23, wherein said catalyst is selected from the group consisting of (1, 5-cyclooctadiene)Ir(PR<sup>C<sub>6</sub>Ar<sup>F</sup></sup>)<sub>3</sub>(pyridine)<sup>+</sup>PF<sub>6</sub><sup>-</sup>,

$(C_5H_5)W(CO)_2(PR^{C_6ArF}_3)(Et_2C=O)^+B(C_6F_5)_4^-$ , and  $(C_5H_5)W(CO)_2(Im^{ArC_6ArF})^+B(C_6F_5)_4^-$ ,

wherein  $R^{C_6ArF}$  is  $C_6F_5(CH_2)_6$ , and  $Im^{ArC_6ArF}$  is represented by formula X



X.